Lightweight Requirements Engineering Assessments in Software Projects

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Lightweight Requirements Engineering Assessments in Software Projects

Daniel Rapp[1], Anne Hess[2], Norbert Seyff[3], Peter Spörri[1], Emmerich Fuchs[1], Martin Glinz[3]

[1] Zühlke Management Consultants AG
Schlieren, Switzerland
{dra, psp, efu}@zuehlke.com

[2] Fraunhofer IESE
Kaiserslautern, Germany
anne.hess@iese.fraunhofer.de

[3] University of Zurich
Department of Informatics
Zurich, Switzerland
{seyff, glinz}@ifi.uzh.ch

***Abstract*—Requirements engineering (RE) is widely recognized as a crucial factor for the success of software projects. Therefore, companies often request assessments of RE processes and resulting artifacts to identify issues and improvement potential. However, industry claims that current assessment approaches do not always fulfill their needs regarding efficiency and effectiveness. Motivated by needs of both, companies asking for an assessment, and a company in the role of an assessor, we have developed a lightweight, tool-supported RE assessment approach. Apart from presenting the approach, we also discuss early experiences we gained from applying our assessment approach in real-world industrial projects.**

***Index Terms*—Requirements engineering assessment, requirements process improvement**

I. Introduction

It is widely recognized in industry that successful requirements engineering (RE) has a tremendous effect on the success of software engineering projects [1] [2]. Hence, when a company becomes aware of problems with its RE processes, it should perform an *assessment* of these processes and then, based on the assessment results, take action for improvement.

Nevertheless, we observe situations where companies experiencing troubles with their RE processes do not take action for improvement or do not act effectively and efficiently. A major reason for such behavior is that companies do not know how to assess their RE processes properly or deem such an assessment to be too complicated and expensive. Other reasons, which we do not address in this paper, could be that such companies lack defined software processes, do not have defined process improvement procedures, are short of resources for process improvement, or just do not recognize the need to change their RE practices [3] [4].

Identifying and choosing an assessment method for RE processes that is effective and efficient in a given situation is indeed a challenge [5] [6] [7].

Several assessment ideas and also concrete concepts including questions have been published in academia and are publicly available [8] [9] [10]. Since these ideas are distributed over different publications, they are hard to identify for companies. Furthermore, these approaches often do not provide clear guidance regarding their actual application and the analysis of results. Likewise, suitable tool support is often limited.

On the other end of the spectrum there are approaches such as CMMI [11] and SPICE [12] which can be applied to a broad range of companies and which assure a standardized assessment. Typically, these assessments allow a company to get professional support by assessors and receive a "rating", which can be communicated to their customers and be used for comparisons to other companies. However, often little details about the assessment method are communicated to companies upfront. This can leave them in uncertainty on what to expect.

For example, concrete questions are often not available to the public which makes it hard to understand to what extent and how a particular assessment approach addresses RE-related problems. Moreover, the application of such approaches requires a certified assessor with specific knowledge. The high cost for such an assessor can be a major obstacle for companies. Finally, preparing for and conducting CMMI or SPICE assessments is time-consuming.

These facts have motivated us to develop the *RE Assessment Guide*, a lightweight, tool-supported RE assessment approach which provides industrial companies with the opportunity to assess their current RE processes efficiently and effectively. The RE Assessment Guide allows to answer questions about the quality levels of RE processes applied in a software development project or organization, such as:

- "Is there a defined RE process to be followed during a particular project?"
- "What kind of activities are performed within the RE process and how are these activities performed in detail?"
- "How are the outcomes of the RE activities documented?"
- "What is the quality of the documented information?"

In our experience, industry requests professional support to answer those questions. So in order to achieve reliable and meaningful assessment results, they want experts to conduct such assessments. Therefore, the assessments conducted with the RE Assessment Guide include an RE expert in the role of the assessor.

The remainder of the paper is organized as follows. Section II highlights needs regarding efficient and effective

assessments. In Section III we discuss existing assessment strategies that have been investigated during the development of the RE Assessment Guide. This discussion is followed by the introduction of the RE Assessment Guide in Section IV. Section V presents experience we gained from first assessments conducted with the help of the RE Assessment Guide in real software projects. The paper concludes with a short summary and outlook on future work in Section VI.

II. Industry Needs Regarding RE Assessments

The RE Assessment Guide is motivated and driven by needs of companies asking for an assessment on the one hand, and companies in the role of assessors on the other hand. We have gathered concrete industry demands regarding RE assessments in discussions with customers over several years. Additionally, we have elicited assessor needs internally in discussions with senior RE consultants.

The subsequent presentation of the elicited needs is structured according to the two viewpoints mentioned above. We distinguish between needs regarding the preparation, the execution, and the analysis phase of an assessment within an organization.

A. Viewpoint of Companies in the Role of Customers

From the viewpoint of companies requesting an RE assessment, the *preparation phase should not require additional effort and should not result in long waiting times until the actual assessment can be conducted* (C1). The execution of the assessments should be efficient, i.e., *the execution should neither involve too many resources, nor require too much time or generate too high costs* (C2). Furthermore, *assessment questions should be easy to understand and to answer* (C3). The analysis phase should be effective, i.e., *the analysis should deliver meaningful, comprehensible, and (statistically) reliable results tailored to particular company needs* (C4). Equally important is that *results should be objective and repeatable, i.e., if more than one expert independently assesses the same process, the analysis should deliver similar results* (C5). *Besides weaknesses and improvement potential, the analysis should also reveal current strengths which should be further retained in the future* (C6). Apart from that, *companies should be provided with clear guidance on how to overcome identified weaknesses* (C7). Finally, *the analysis should also reveal a "rating" illustrating the current standing of the company in comparison to other companies* (C8).

B. Viewpoint of Companies in the Role of Assessors

From the viewpoint of companies which would like to conduct assessments, an efficient and effective preparation should be supported. That is, *it should be easy to adapt the assessment to specific company and project characteristics and to particular customer needs* (A1). Furthermore, *the preparation phase should not take too much time and involve too many stakeholders from the customers' side to deliver information* (A2). For members of a company offering such assessments, *it should be easy to learn how to conduct the assessments* (A3). *No exhaustive and expensive training should be necessary, assuming that future assessors already have RE knowledge* (A4).

The execution of an assessment should also be efficient and effective. That means that *the execution should not require too much time, generate too high costs and require too many resources* (A5). Apart from that, *the assessor should be able to tailor and focus assessment questions to particular information gained during an assessment session and detect connections between different answers* (A6). In order to finally deliver meaningful results, *it should also be possible to get deeper insight into interesting aspects during discussion and to easily document discussion results* (A7).

Finally, there are also several demands regarding efficiency and effectiveness of the analysis phase where information collected during an assessment is analyzed and communicated to the customer. These demands include *fast and reliable result analysis and preparation (e.g. by using statistical analysis approaches)* (A8), *being able to get a good understanding of current problems, their reasons and their severity to identify suitable improvement strategies* (A9).

III. Related Work

This section gives an overview on existing assessment strategies that have been investigated during the development of the RE Assessment Guide. We briefly introduce each approach and discuss it with respect to its relation to the RE Assessment Guide.

The *Capability Maturity Model Integration* (CMMI) [11] and the *Software Process Improvement Capability Determination* (SPICE) [12], also known as ISO/IEC 15504, are prominent maturity models for assessing and improving software development processes [13]. In order to determine the maturity level of a particular software development process, key software engineering activities are analyzed, including RE activities. The latter activities comprise, for instance, *develop customer requirements*, *develop product requirements* or *analyze and validate requirements*. Since the application of these models is quite extensive, their usage for conducting RE assessments is rather complex and time consuming [5]. Thus CMMI as well as SPICE are inadequate for performing an efficient RE process assessment within a short amount of time. However, both approaches give a good overview on how RE activities have to be performed and have served as valuable input during the development of the RE Assessment Guide.

The *Software Product Management Maturity Matrix* (SPMMM) [8] provides guidelines on how to optimize software product management processes. To determine the maturity level of a software product management process, requirements management activities and related tasks are also investigated. The detailed descriptions of these activities and tasks have been considered as a basis for the assessment criteria of the RE Assessment Guide. This input includes especially tasks related to activities such as *requirements gathering*, *requirements identification*, *requirements organizing*, *requirements prioritization*, *release definition and validation*, and *scope change management*. However, SPMMM is not RE-specific, but focuses on the entire software product

management lifecycle. For example, the SPMMM does not consider requirements artifacts in detail. Hence, this framework cannot be used out-of-the-box for assessing the quality of a given RE process.

Within the scope of the *ReqMan* research project, a framework has been developed which aims at optimizing RE processes of small to medium-sized enterprises (SME) [4] [14] ReqMan investigates typical RE-related activities such as *requirements elicitation*, *requirements analysis*, *requirements specification*, *requirements verification and validation* as well as *requirements management*. For each of these activities, the framework defines basic, advanced and optimized practices and related techniques. Considering, for example, the activity *requirements validation*, a basic practice would be *review requirements* with a corresponding technique like *checklist-based reading*. An advanced practice for this activity would be *prepare tests for requirements,* and an optimized practice would be *prototyping* [14]. Even though the aim of ReqMan is quite similar to the aim of the RE Assessment Guide, i.e., allow efficient and effective RE assessments, the ReqMan solution approach is different. ReqMan provides a tool-supported method that enables companies to evaluate and improve their established RE processes on their own without the necessity to hire an external assessor. That is, based on the detailed descriptions of activities, practices and related techniques that are provided by the framework, companies can easily evaluate their current implementation status of RE practices and identify and incorporate improvement potential. Similar to the activities and tasks defined within the SPMMM, the detailed descriptions of practices have been used as input for assessment criteria of the RE Assessment Guide.

The *Requirements Capability Maturity Model* (R-CMM) [9] describes what kind of RE processes an organization has to establish to reach a certain maturity. R-CMM is based on the RE processes defined in CMMI, and has the intention to specify the rather abstract CMMI RE processes in more detail. The aim of R-CMM is to provide a framework for companies that supports the implementation of their RE processes according to a target process maturity. Since processes and sub-processes are solely defined for maturity level 2 (repeatable software processes), R-CMM does not suffice to conduct an entire assessment and to determine the maturity level of the RE process in a concrete software development project. However, the detailed process definitions regarding maturity level 2 have been implemented as assessment criteria in the RE Assessment Guide.

The *Requirements Engineering Reference Model* (REM) [10] is a reference model which defines RE artifacts, their desired contents and their dependencies. In their work, Geisberger et al. describe in detail which artifacts are needed within an RE process and what the aim of each of these artifacts is. Especially the part *requirements specification* has turned out to be a relevant source for the RE Assessment Guide. We have used it as a basis for defining the assessment criteria for the document analysis part. However, due to its specialization on RE artifacts, REM is not appropriate to be used solely for the execution of assessments regarding the entire RE process in software development projects.

To summarize, there are several maturity models and assessment approaches that support the analysis of current RE processes established in software development companies. These approaches include highly useful concepts and each approach supports a specific purpose. Some of these ideas have been incorporated in our RE Assessment Guide. However, having conducted this analysis, we also concluded that none of these approaches fulfills our needs regarding efficient and effective RE process assessments as discussed in Section II. For example, some approaches focus on the complete software engineering process and investigate RE-related activities only on a quite abstract level, as it is the case for SPMMM. Other approaches do aim at enabling efficient and effective RE process assessments, but follow a different solution approach such as cooperative self-assessments provided by the ReqMan framework. Other approaches focus on particular assessment aspects only. For example REM concentrates on the quality of RE artifacts and does not consider the RE process or activities in detail.

As a result, we decided to develop an independent RE Assessment Guide on the foundation of the strengths of the described maturity models and assessment frameworks.

IV. The RE Assessment Guide

The development of the RE Assessment Guide was motivated by our vision of a lightweight and structured method to answer questions regarding the quality of RE processes (see Section I) and to meet demands of both industry and assessors (see Section II).

In addition, it should be possible to adapt the RE Assessment Guide to the characteristics of a concrete software project and the developing organization to consider the heterogeneity of different software development projects. Furthermore, to support a standardized assessment, the RE Assessment Guide should be implemented in a tool to be used by the assessor which also supports the result analysis of the conducted assessments.

We have developed the RE Assessment Guide in an iterative manner, testing early prototypes within internal projects and using the feedback gathered for guiding the further development. The assessment criteria that we have implemented in the RE Assessment Guide mainly stem from an analysis of existing assessment approaches (as introduced in Section III) as well as from RE related literature such as [15] [16] [17] [18] [19]. We have identified further assessment criteria by means of expert interviews. We have conducted these interviews to get an impression of how RE is performed in practice within software development companies.

In the remainder of this section, we describe the implementation structure and application of the RE Assessment Guide in detail.

A. Implementation Structure

Technically, the Assessment Guide is implemented in LimeSurvey [20], an open-source-tool for creating and

conducting surveys. In its current version [22], the RE Assessment Guide is divided into three main parts: (1) influencing factors, (2) process analysis, and (3) document analysis. While part 1 is always executed, it is possible to decide whether the assessment should only include document analysis, process analysis or both. For example, if a customer is primarily interested in assessing the quality of artifacts created during current RE activities, only the document analysis part can be conducted together with the analysis of influencing factors. The assessment criteria of each of these parts are implemented in the form of concrete questions which can be answered on a scale from 1 = "Definitely yes" to 4 = "Not at all" and be supplemented with comments. There is also the option to give no answer to a particular question. Figure 1 shows an example question from the RE Assessment Guide with the five answer options and a field for free-form comments. The assessor fills in this survey during an assessment interview based on the answers given by the interviewee (see step 3 in Section IV.B) or answers these questions during the document analysis (see step 4 in Section IV.B).

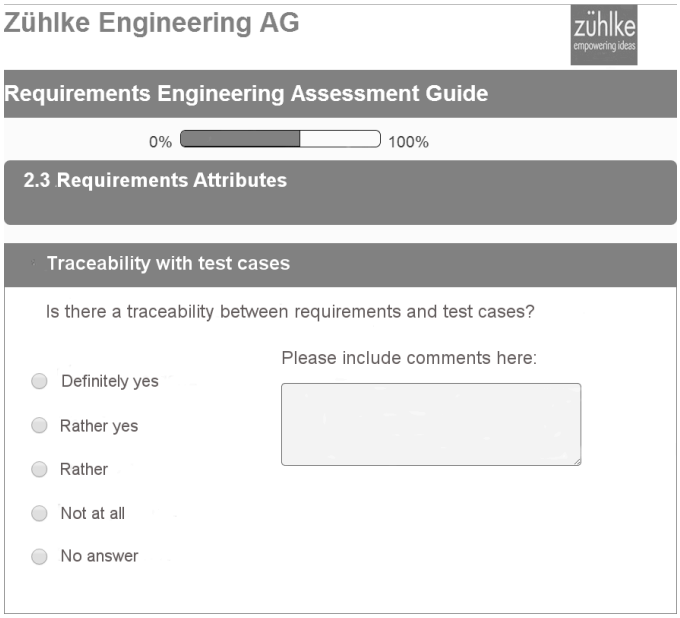

Fig. 1. RE Assessment Guide – Example Question

Subsequently, we describe the three parts and corresponding assessment criteria in more detail.

Part 1 - Influencing Factors

This part includes assessment criteria related to general project-specific information, comprising, for instance, company size, business areas, and roles that are involved in an investigated project. Assessment criteria of this part include questions such as:

- "In what kind of business areas is your company operating?"
- "How many employees does your company employ?"
- "How many full-time equivalents are working in the investigated project?"
- "What roles do these equivalents have within the investigated project?"

Part 2 - Process Analysis

In this part, detailed information is elicited regarding underlying process models (e.g. waterfall approach or iterative approach), RE processes and activities followed as well as communication flows within the project. Assessment criteria related to process analysis include:

- "Do you follow a defined RE process?"
- "Do you perform the following RE activities, e.g. elicitation, validation, negotiation, documentation and management?"
- "Do you integrate all relevant stakeholders in requirements elicitation, e.g. customers, internal stakeholder, partners or end-users?"
- "Do you prioritize your requirements together with your stakeholders?"
- "Do you have a defined requirements change management process in place?"

Part 3 - Document Analysis

This part is dedicated to eliciting detailed information about artifacts / documents that have been specified within an investigated project. For each artifact, detailed information is captured regarding notations, when it was initially created (e.g. in the inception phase), if and when it was refined (e.g. during elaboration time), when it was communicated to other team members, etc. Further assessment criteria regarding the document analysis part include, for example:

- "Do you iteratively create your documentation?"
- "Is there a unique identifier for each requirement?"
- "Do you document the status for each requirement?"
- "Do you document the author for each requirement?"
- "Do you document the acceptance criteria for each requirement?"
- "Do you link dependent requirements?"
- "Do you link requirements with test cases?"

B. Assessment Lifecycle with the RE Assessment Guide

The RE Assessment Guide focuses on project rather than company assessments. However, identifying "typical" projects or assessing a larger number of projects within a company is supported and allows to draw conclusions about the general quality of the RE process within a company. Typically, a project assessment is conducted by an assessor who interviews one or more representatives of the customer company who have been involved in the RE activities of the project under investigation. The RE Assessment Guide guides the assessor through the various questions eliciting information about

influencing factors, processes and documents, whereby it dynamically adapts the questions to given answers based on predefined dependencies. For example, only if the question "do you integrate the customers in the requirements elicitation?" is answered with "definitely yes" or "rather yes", the subsequent question "How often do you elicit requirements from the customer?" is displayed in the RE Assessment Guide. Similarly, if there are no use cases created within the project, the assessment criteria regarding how the use cases are documented in detail will not be asked.

As illustrated in Figure 2, a typical assessment lifecycle with the RE Assessment Guide comprises six steps that we describe subsequently. The information about participants and duration of each step are based on our first experience with conducting assessments (see Section V.A).

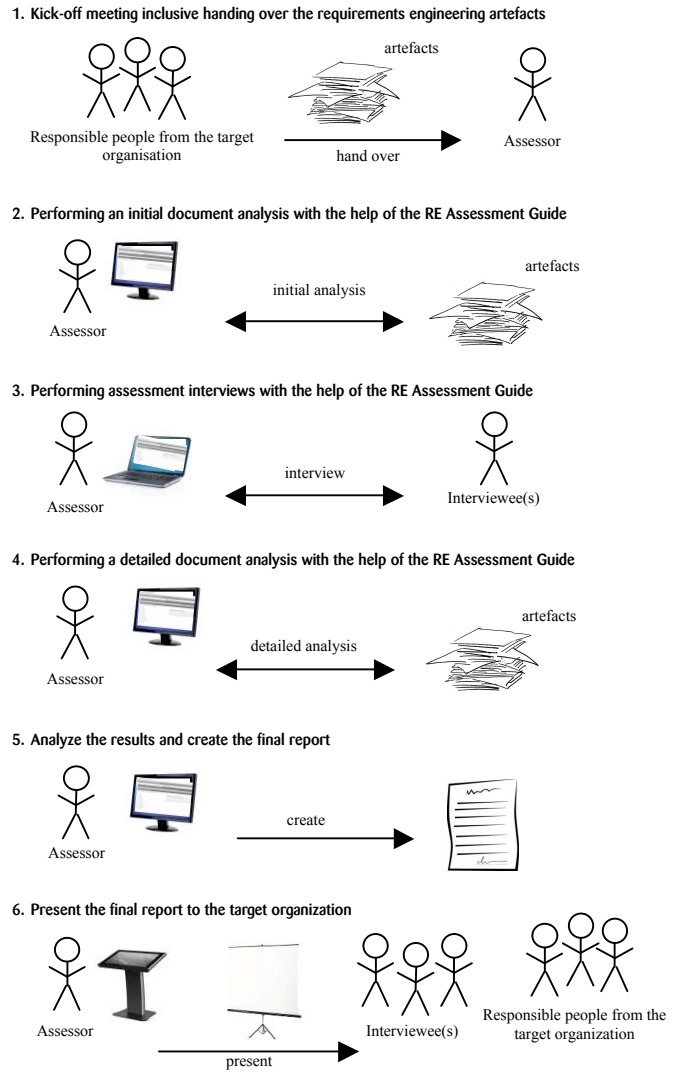

Fig. 2. Assessment Lifecycle with the RE Assessment Guide

Step 1 - Kick-off Meeting
(Participants: assessor and customer representatives; Duration: ~1 hour)

In the first step of an assessment, the assessor organizes a kick-off meeting with the customer, i.e., the company that requests the assessment. The goal of this meeting is to explain how an assessment is conducted and to discuss organizational issues such as the time plan for the interview session(s) (see step 3) and the final presentation (see step 6). Shortly after the kick-off meeting, the customer hands over relevant RE artifacts, (e.g. the requirements specification) which will be analyzed by the assessor in the subsequent steps 2 and 4.

Step 2 – Initial Document Analysis
(Participant: 1 assessor; Duration: ~4 hours)

In this step, the assessor initially analyzes the RE artifacts that were handed out by the customer (see step 1). The goal of this analysis is to get a first impression about how RE is done at the customer's side. Additionally, this analysis serves as a means for initial identification of interesting aspects and open issues that should be focused on and discussed in further detail during the interview session (see step 3). The output of this step is an overview of existing artifacts and questions about the artifacts which can be raised during the interviews.

Step 3 – Assessment Interviews
(Participants: 1-2 assessors and 1-5 customer project team members; Duration: ~2 hours per interview)

The goal of this step is to perform an assessment interview with one or more interviewee(s) who are actively involved as team members in the investigated software development project. In order to get a differentiated view on the RE process, it is possible to involve interviewee(s) who have different roles within the software development project. This step results in detailed insight into how the RE process is performed within the investigated project. Optionally, follow-up interviews may be conducted to clarify any issues raised in interviews or found after interviews, for example, by cross-checking initial interview results and documentation.

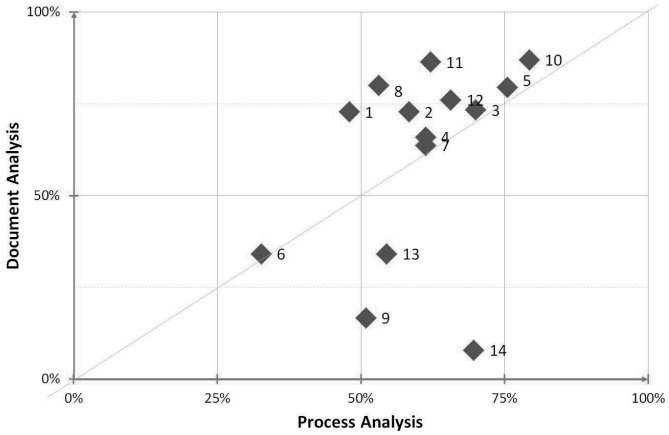

Fig. 3. Matrix visualizing comparisons of different assessments. The matrix shows the percentages of questions in the parts 'Process Analysis' and 'Document Analysis' that were answered with "definitely yes" or "rather yes". Each diamond represents one of the conducted assessments.

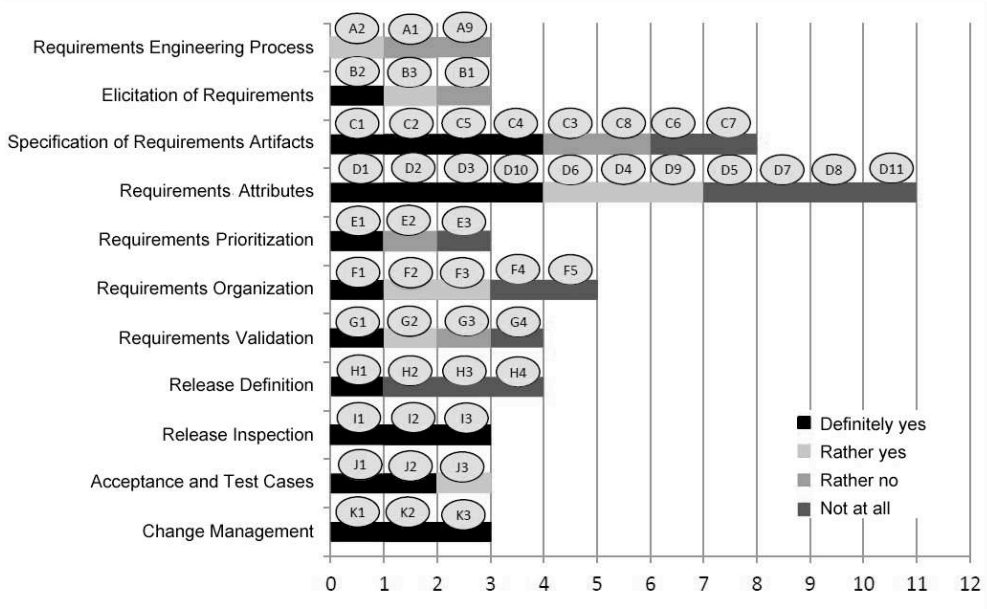

Fig. 4. Extract from result analysis visualizing results of all assessment criteria (A2 – K3) grouped by the assessment categories (Requirements Engineering Process, Elicitation of Requirements, Specification of Requirements Artifacts, etc.)

Step 4 – Document Analysis Continued
(Participant: 1 assessor; Duration: ~8 hours)

Similar to step 2, a document analysis is performed with the help of the RE Assessment Guide. This time, it is a more detailed analysis on the basis of the insights gained from the assessment interview(s) conducted in step 3. At the end of this document analysis activity, the investigation of the artifacts is finished and all assessment criteria included in the assessment guide are answered.

Step 5 – Result Analysis and Report Creation
(Participant: 1 assessor; Duration: ~16 hours)

After conducting the interview(s), the assessor has to analyze and evaluate the captured data both from the document analysis (steps 2 and 4) as well as from the conducted interview(s) (step 3). Result analysis is supported by diagrams which can be generated with the LimeSurvey tool [20] to get an overview about the quality of the assessed RE process. Figures 3 and 4 show examples of result diagrams.

All results gained by the data analysis are documented in a final report. The report summarizes the major findings of the quality assessment of the investigated RE process, including strengths, weaknesses and improvement potential. Thus, the outcome of step 5 is the final report which will be handed over to the customer.

Step 6 – Final Presentation
(Participants: 1 assessor and customer representatives; Duration: ~1 hour)

Finally, the last step of the entire assessment lifecycle is to present the results of the RE assessment to the customer in a meeting. Relevant people from the customer's side who have an interest in the assessment results (such as team members of the investigated software development project, members of other projects or the management of the company) should be invited to this meeting.

Analysis of Overall Effort

In summary, conducting a typical assessment with the RE Assessment Guide requires the following overall efforts both from customer's and assessor's sides:

- Each customer representative participating in the kick-off-meeting (step 1), the interview (step 3) and the final presentation (step 6) spends about four hours overall. In a typical project setting, there are three team members involved. Thus, based on our experience, the overall effort on the customer side is about twelve hours. Of course, the effort required depends on the organization's setup for the assessment. For example, the effort will increase if the organization decides to invite a larger audience to the final presentation meeting.
- One assessor is required for the kick-off meeting (step 1), document analysis (steps 2 and 4), report creation (step 5) and final presentation (step 6). We often had two assessors who were conducting the assessment interviews (step 3). Typically, we conduced three assessment interviews. This results in a total of about 42 hours spent on the assessors' side.

V. First Experience

In this section, we present early experience we gained from the application of the RE Assessment Guide in real-world projects. The lessons learned discussed in this section summarize our own experience gained by different assessors (three of the authors) who have used the RE Assessment Guide

in customer projects. Furthermore, the lessons also reflect customer feedback we gained during discussions with customer representatives who have been actively involved in the project assessments. We first introduce the project settings and particular goals. Then we report on the lessons learned.

A. Assessment Project Settings and Goals

So far, the RE Assessment Guide has been applied in ten industrial software development projects. These projects typically involved three to seven full time equivalents, comprised a total effort of 600-1500 person days, and had a project duration of 12-18 months. Nine out of the ten projects followed an iterative software development process, whereas one project followed a waterfall approach.

The ten assessment projects can be categorized into three types of assessments based on the individual customer needs.

1) The goal of three assessment projects was to analyze the quality of current RE processes. The assessment was conducted after the elaboration phase (following the Rational Unified Process [21] in order to identify possible weaknesses and improvement potential that could be addressed in later phases (i.e. the construction phase).
2) The second assessment type was targeted to compare how RE is performed in several software development projects within one company. This assessment can, for example, be used to evaluate how a defined RE methodology is applied in different project settings. This assessment was conducted for six projects in two companies (two projects in one company, and four projects in the other company).
3) The third type of assessment conducted in one company had its focus on the investigation of communication flows within the project teams. That is, the assessment interview was conducted with different roles that were involved in the investigated projects. The goal was to investigate how requirements are communicated (e.g., in meetings, in different documents or in centralized documents) and to reveal any problems (e.g., whether the documentation of requirements is sufficient for testers to derive test cases, or whether relevant requirements artifacts are missing from the viewpoint of software architects, etc.).

Besides the projects mentioned above, the assessment guide was also applied within 27 projects in a semi-industrial environment. This means that up to 9 undergraduate computer science students in their first and second year were acting as a software development team and had a real industrial customer. To our experience, these projects are very similar to software development projects in industry, as a "real-life" customer provides a problem, which needs to be solved by a software system. Thus the project team has to deliver running software by a certain deadline just as real-world software development projects have to. Moreover, the project teams had to perform the entire software development process from the first contact with the customer to the delivery of the software system on their own. The project team members had to communicate directly and independently with the customer, identify relevant stakeholders and further information sources, and decide which artifacts to produce at what point of time in the project.

In this context we conducted assessments with the help of the RE Assessment Guide to evaluate the quality of the RE processes applied in early project phases (i.e., during the elaboration phase based on the Rational Unified Process [21]. The goal was to identify weaknesses which should be improved to avoid problems in later project phases (similar to the first type of assessments mentioned above). We are aware that these student projects are not fully equivalent to industrial projects. However, these projects also allowed us to apply and test the RE Assessment Guide in a homogenous, stable and comparable environment that we could control to some degree.

B. Lessons Learned

In this sub-section, we discuss the lessons learned from applying the RE Assessment Guide in real-world projects. The lessons are primary based on the experience gained during the application of the RE Assessment Guide in the ten industrial software development projects. However, some lessons (especially those from the assessor's viewpoint) have also been experienced in the semi-industrial setting. The lessons are partially traced to the industry needs discussed in Section II of this paper.

The flexibility of the RE Assessment Guide enables tailoring the assessment to customer-specific projects and assessment needs (A1, A6). As discussed previously in Section V.A, the RE Assessment Guide has successfully proven to be applicable in different project settings with different customer goals. Furthermore, it is possible to use the RE Assessment Guide in various settings, such as single projects, programs which comprise several projects, business unit methodologies, competence centers which are responsible for RE in a company, etc.

The RE Assessment Guide can be applied with a limited amount of time and resources (A2, A5, C1, C2). We found that companies clearly do not want to spend much time on assessments. However, a typical assessment lifecycle (as discussed in Section IV.B) requires customer involvement during certain steps in the assessment. The overall effort that the customer has to spend during a particular project is about four hours per involved person (see also Section IV.B) based on our experience gained during the assessments conducted so far. None of the customers complained about the time needed for the assessments. On the contrary, some customers were even positively surprised about the required effort. They initially expected to have to spend more time in the assessment process. However, the limited amount of time and resources needed from the companies needs to be compensated by an in depth document analysis which is done solely by the assessor (see steps 2 and 4 in Section IV.B). This analysis delivers meaningful results to the customer without requiring any time resources on the customer's side.

High quality specifications reduce the time involvement needed from customers (C2). We have experienced that the quality attributes of a specification (e.g., completeness, traceability, understandability) also influence the time needed for an assessment. In particular, high quality specifications enable the assessor to perform a thorough document analysis (see steps 2 to 4 in Section IV.B) without the need of extensive

interaction and communication with customer representatives. However, in case of low quality specifications, missing information needs to be discussed with customer representatives and more interviews are necessary in order to identify reasons and get explanations.

Assessment questions are easy to understand by the customers (C3). The application of the RE Assessment Guide has revealed that the assessment questions of the current version of the RE Assessment Guide are easy to understand by the interviewees, so that they can give suitable answers to these questions. Applications of previous prototype versions of the RE Assessment Guide have revealed some inconsistencies and ambiguities in the questions which have been tackled during the iterative development of the RE Assessment Guide.

Comments and open discussions are very important (A7, A9). As described above, the standardization of answers to the assessment questions is very useful to allow comparisons between different assessments. These answers alone, however, are not sufficient to identify suitable improvements and to provide guidance to the customer to realize these improvements. Therefore, it is very important to collect and record any comments given by the customers, which basically provide the rationale for certain answers.

Selection of suitable interviewees and moderation skills by the assessor are very important. We found that it is important to include the "right" people to get meaningful results. In order to get true answers, it is also very important that the assessment does not have the smell of marking the customer, but to find possible improvements.

Differences in answers given by several people are hard to detect during the assessment interview (A6). The possibility to conduct the assessment interview with up to 5 persons (even with different roles in a particular project) is also considered to be very valuable for customers as it enables to share their opinions regarding RE activities, which in turn fosters the communication between the team members. During the application of the RE Assessment Guide with several people involved in one particular project (see third project type in Section V.A) we experienced that different people have sometimes different opinions regarding a particular assessment criterion. For example, one interviewee in the role of a requirements engineer totally agreed that all requirements are accessible at a centralized location whereas a tester claimed that this criterion is not fulfilled at all. In such cases it would be very interesting to further discuss such diverging opinions, but this requires that the assessor is aware of them during an assessment interview. However, this is quite hard especially when several assessments interviews are conducted within one project.

Document analysis is very beneficial. Our experience highlights that the document analysis activities (see step 2 and step 4 in Section IV.B) deliver meaningful results. That is, the document analysis which is conducted prior to the assessment helps to get initial insights into current RE activities and to identify interesting aspects that should be further discussed during the assessment interview(s). The second document analysis, which is conducted after the assessment interviews have been performed, focuses on the detailed analysis of the documents with the help of the RE Assessment Guide. These results can then be included in the final report to support and supplement any descriptions of findings revealed during the data analysis of the interview result. Even though the document analysis requires additional effort for the assessors and is often not so easy, it helps to improve the quality of the results delivered to the customer and hence to increase the customer satisfaction.

The assessment delivers meaningful results to the customers (C4, C6, C7, C8). Meaningful and understandable results are very important outcomes for the customers. This includes feasible and manageable suggestions regarding possible improvements supplemented with concrete actions to realize these improvements. Based on the customer feedback we gained from the initial assessments during discussions, we conclude that the assessment results are very helpful to the customers to detect weaknesses and improvement potential within their current RE processes. Especially the fact that answers to the assessment questions are standardized (i.e., answers can be given on a scale from "definitely yes" to "not at all", cf. Section IV.A) makes it possible to compare assessment results of a particular project to other conducted assessments (see Figure 3). Thus, it is possible to compare different projects within one company, but also compare the current standing of a company in comparison to other companies. Especially the latter aspect is worthwhile for the customers (see requirement C8 in Section II.A). However, in order to improve such comparisons of assessment results with other similar companies or projects, *it would be necessary to provide more statistical data*, e.g. how projects with a similar setup in terms of full time equivalents, budget and stakeholders have been assessed or which artifacts have usually been created in comparable projects. Even though it is currently possible to gather this data during each assessment, a detailed analysis and preparation of such comparisons is not efficient yet and hence the corresponding requirement (C8) is not fully met. This is mainly due to the fact that the LimeSurvey analysis engine is not very powerful. So huge manual effort is required for creating valid statistical data analyses. Future work aims at improving this issue.

The assessment delivers objective and repeatable results to the customers (C5). The presented RE Assessment Guide is a framework, which was designed to support RE experts in conducting RE assessments. The questions guide the expert, but are presented at a level of detail where it is still up to the expert to make interpretations and to tailor the questions to the actual project under analysis (e.g., the interpretation of the question "Do you integrate all relevant stakeholders in requirements elicitation" (see Section IV.A), could vary from one expert to another due to different opinions regarding relevance of stakeholders). This could mean that different experts would come up with different results using the RE Assessment Guide in the same project. However, this is not what we experienced in the assessments conducted so far. For some projects, more then one expert was involved and both experts performed the document analysis individually. In those

cases there was hardly any difference in the outcomes. In our opinion, this can be explained by the fact that both experts share a similar understanding of RE, which should be the case for experts within one company.

Report generation requires too much effort (A8). The main effort for the assessors is the creation of the final report. As described in Section IV.B, this activity currently requires about sixteen hours of work, especially since the tool chain (LimeSurvey, office tools) is not fully automated. In the current version of the tool, a semi-automatic report generation based on Visual Basic Macros is already possible. However, there is still a lot of work which has to be done manually such as copying the diagrams into the final report or maintaining the results matrix. As soon as it is possible to generate the structure of the final report including diagrams and comparisons to other projects automatically, the duration of one assessment could be further reduced.

Refinement of possible answers would be helpful. To allow comparisons between different assessments, the assessment criteria of the RE Assessment Guide have been implemented in the form of questions that can be answered on a scale from 1 = "Definitely yes" to 4 = "Not at all" (cf. Section IV.A). However, the answers that are given are currently based on the personal evaluation of the interviewee. Often it is also hard to distinguish between "Definitely yes" and "Rather yes". To achieve more reliable results, it would be helpful to supplement the possible answers with further criteria that provide guidance to select an appropriate rating. For example the answers of the assessment criteria "Are the requirements prioritized?" can be refined into "Definitely yes: at least 90% of the requirements are prioritized", "Rather yes: 60 – 90% of the requirements are prioritized", "Rather no: 30 – 60% of the requirements are prioritized" and "Not at all: <30% of the requirements are prioritized".

The RE Assessment Guide requires maintenance effort. At the moment it is hardly possible to add or remove assessment criteria and their relations while keeping collected assessment data for comparisons. Such updates require changes in the database, i.e., a new database has to be set up and all assessment data which has already been gathered has to be copied to the new database. This effort increases with the number of conducted assessments.

The RE Assessment Guide can be used without extensive training, but its application requires RE knowledge (A3, A4). The first applications of the RE Assessment Guide by different people have revealed that the guide and tool can be easily used without extensive training. However, in order to lead discussions during the interview and to analyze the results regarding strengths, weaknesses and improvement potential, the assessor needs to have sound RE knowledge. We have also observed that after the RE Assessment Guide has been used several times, the assessors become familiar with the questions so that the interview can be conducted freely without "sticking" to and focusing on the tool.

The RE Assessment Guide supports providing "ad-hoc" RE assessments. As the RE Assessment Guide is easy to understand and learn by a person who has RE knowledge, a broader range of potential assessors can be made available in a relatively short period of time. Having an adequate number of assessors also means that waiting times for companies can be quite short if needed. Companies can further select an assessor who suits their needs best. For example, an assessor who has some domain knowledge or is locally available can be chosen.

VI. Summary and Future Work

Based on a discussion of industry needs regarding RE assessments both from the viewpoint of companies requesting RE assessments, and of companies in the role of an assessor, the paper has introduced the RE Assessment Guide – a lightweight tool-supported RE assessment approach. Besides a discussion of related work, the paper has described the implementation structure as well as a typical assessment lifecycle with the RE Assessment Guide.

Finally, the paper has shared early experience that we gained during 37 project assessments that have successfully been conducted with the help of the RE Assessment Guide.

Future work aims at addressing weaknesses that have been revealed during these applications. This includes technical improvements such as automated report generation to save manual effort, automated statistical analysis to support comparisons between different assessments or tool-supported maintenance to allow simplified adding and removing of assessment criteria.

With respect to the functionality of the tool, assessors would highly appreciate tool support for comparing, in real time, answers in an interview that they are currently conducting to answers and analyses from past assessment interviews. The availability of such an interview tool, which provides a sophisticated guidance mechanism, could reduce follow-up effort required to clarify any issues in further interviews.

In addition to these technical improvements, it would also be worthwhile to invest work into the refinement of questions and answers to further improve assessment results. Such a refinement could be done in various directions. For example, assessment criteria could be extended to questions investigating specific software project characteristics such as compliance to regulatory issues (e.g., medical standards) or criticality of software applications, (e.g., regarding reliability, safety, or security requirements).

Moreover, in the future, the RE Assessment Guide could also be adapted to specific project settings such as RE in systems engineering projects, RE in agile projects, RE in mechatronic projects, RE in near- / offshoring projects, etc.

Because this approach is to some extent a survey approach, it would also be worthwhile to review the research literature with respect to the composition of unbiased survey questions and tune questions systematically.

We also plan to improve the result analysis and report generation capabilities of the RE Assessment Guide. The goal is to make the assessment results better comparable between different companies. This could also mean to refine the rating system itself (e.g. by considering a different weighting of questions and answers).

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